A Preliminary Investigation of Aerogravity Assist at Triton for Capture into Orbit About Neptune

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Motivation

Atmospheric entry speeds at Neptune are inherently very high (typically 28-30 km/s)

As a result, recent studies have shown that direct aerocapture at Neptune will require aeroshell mass fractions in excess of 50%

Previous work by our group has shown that an aerogravity assist (AGA) at *Titan* has promise as a means of capturing a vehicle into orbit about *Saturn*

Such a maneuver would entail much lower entry speeds than a direct aerocapture and would result in a less severe aerothermal environment

Objectives

Present study seeks to determine if an aerogravity assist at Triton is feasible as a means of capture into orbit about Neptune

Evaluate entry corridors as a function of atmospheric entry speed

Determine the characteristics of a vehicle necessary to accomplish the proposed maneuver

Determine the impact of off-nominal atmospheric conditions on vehicle design and maneuver feasibility

Triton - Basics

A diameter of 2700 km - by far the largest of Neptune's moons

Near-circular, retrograde orbit at 355,000 km radius with a 157 degree inclination

Orbital speed about Neptune of 4.4 km/s

Extremely tenuous atmosphere, primarily nitrogen with a small percent methane

Surface pressure of approximately 0.016 *millibar* with a large temporal variation

Mission Assumptions

Triton entry speeds from 4.7 to 22 km/s (corresponding to Neptune entry speeds of 24 to 34 km/s)

Target orbit about Neptune 355,000 km apoapse and 29,000 km periapse (based on previous Neptune aerocapture studies by Lockwood et al)

A nominal target for the Triton atmospheric exit velocity of 3.0 km/s (if the outbound trajectory is opposite to Triton's orbital velocity, this gives a periapse at the specified 29000 km radius)

Methodology

Trajectory simulations carried out with 3D POST

Due east, equatorial entries

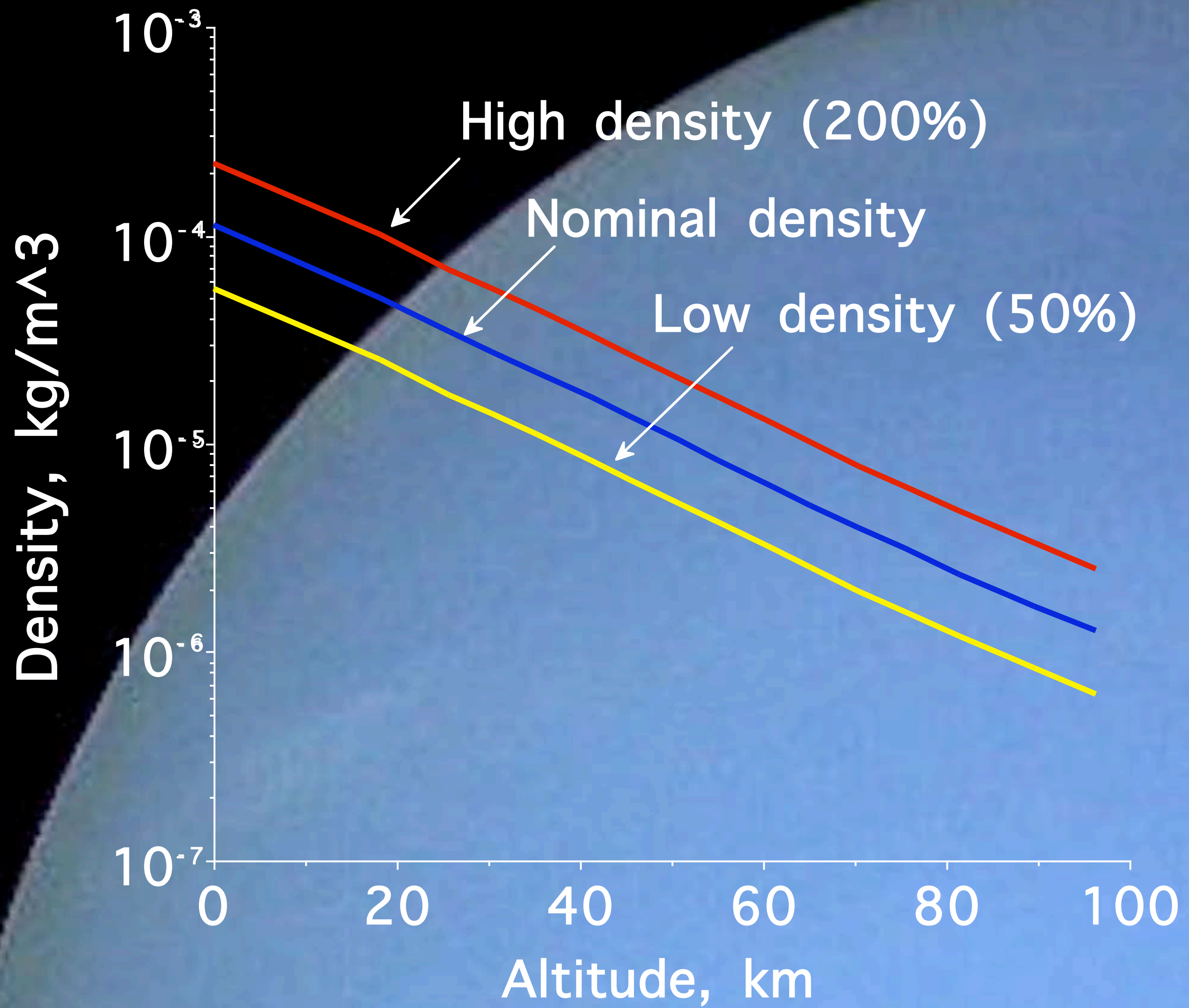
No winds or horizontal density dispersions were considered

Entry interface at 95 km altitude

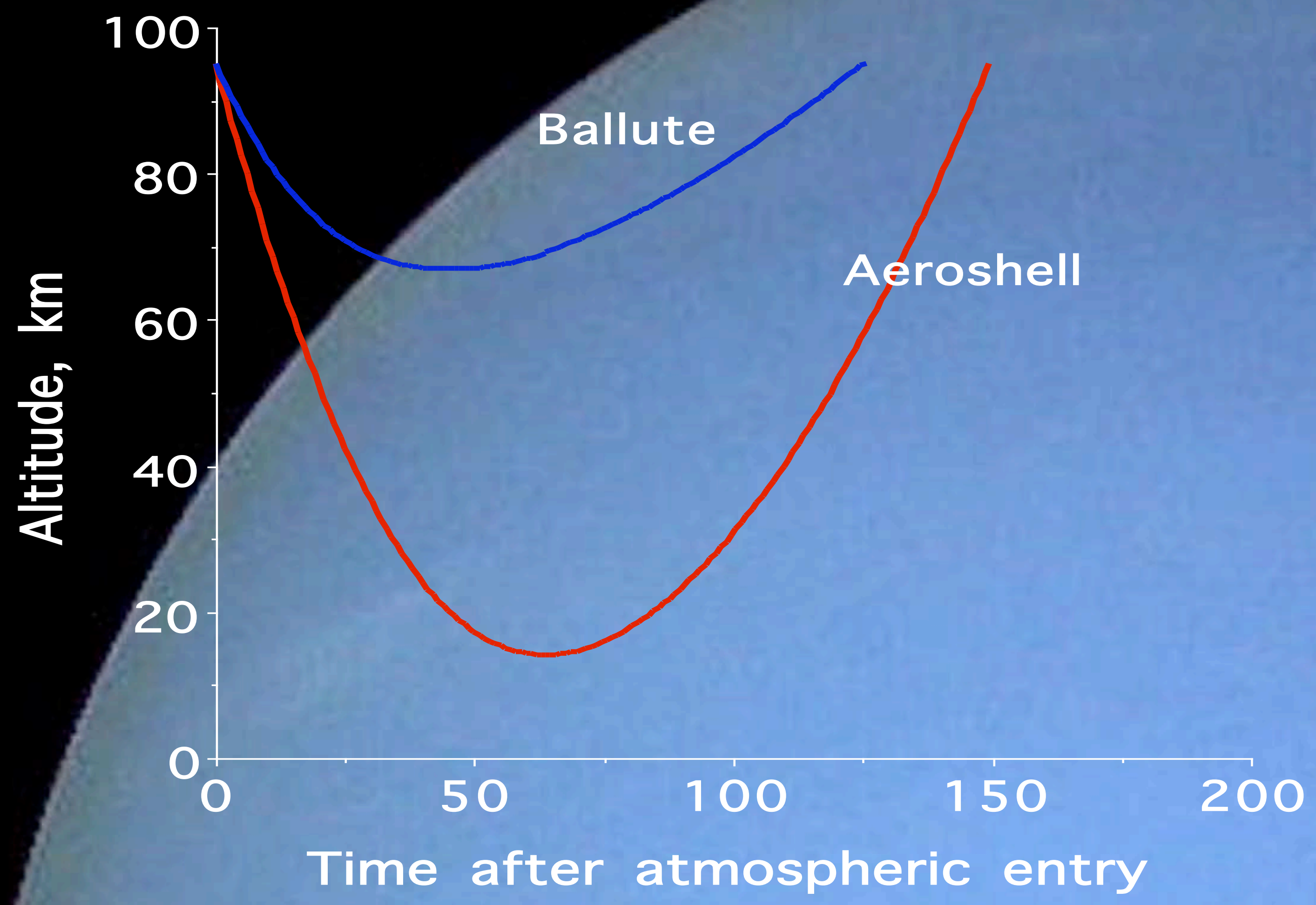
Assumed probe mass is 600 kg

Toroidal ballute used with C_D= 1.46 and area ranging from 100 to 1500 m^2

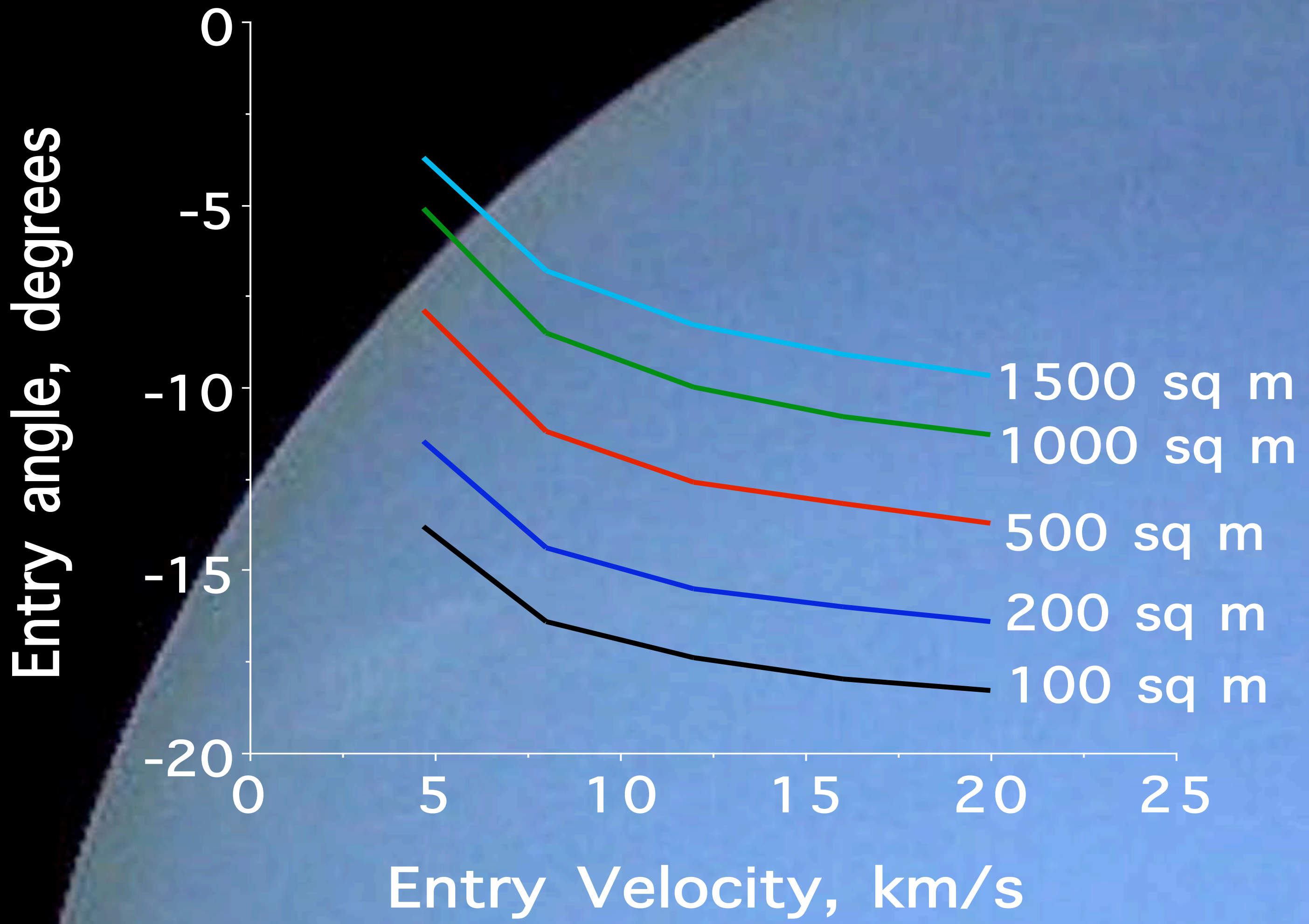
Triton Atmospheric Model Based on Stellar Occultation Studies



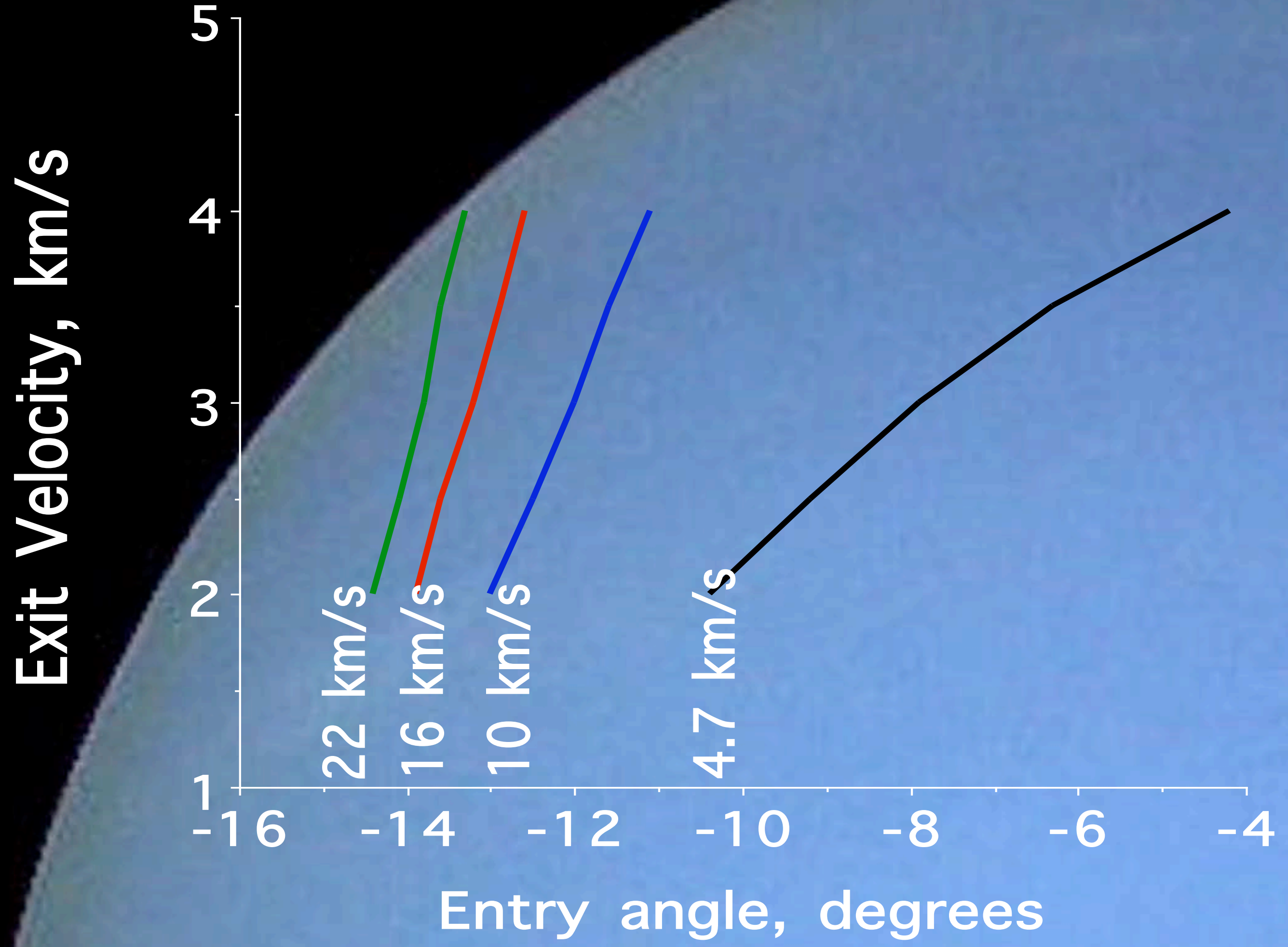
Altitude History of a Rigid Aeroshell and Ballute During Overshoot Trajectory for an 8 km/s Entry



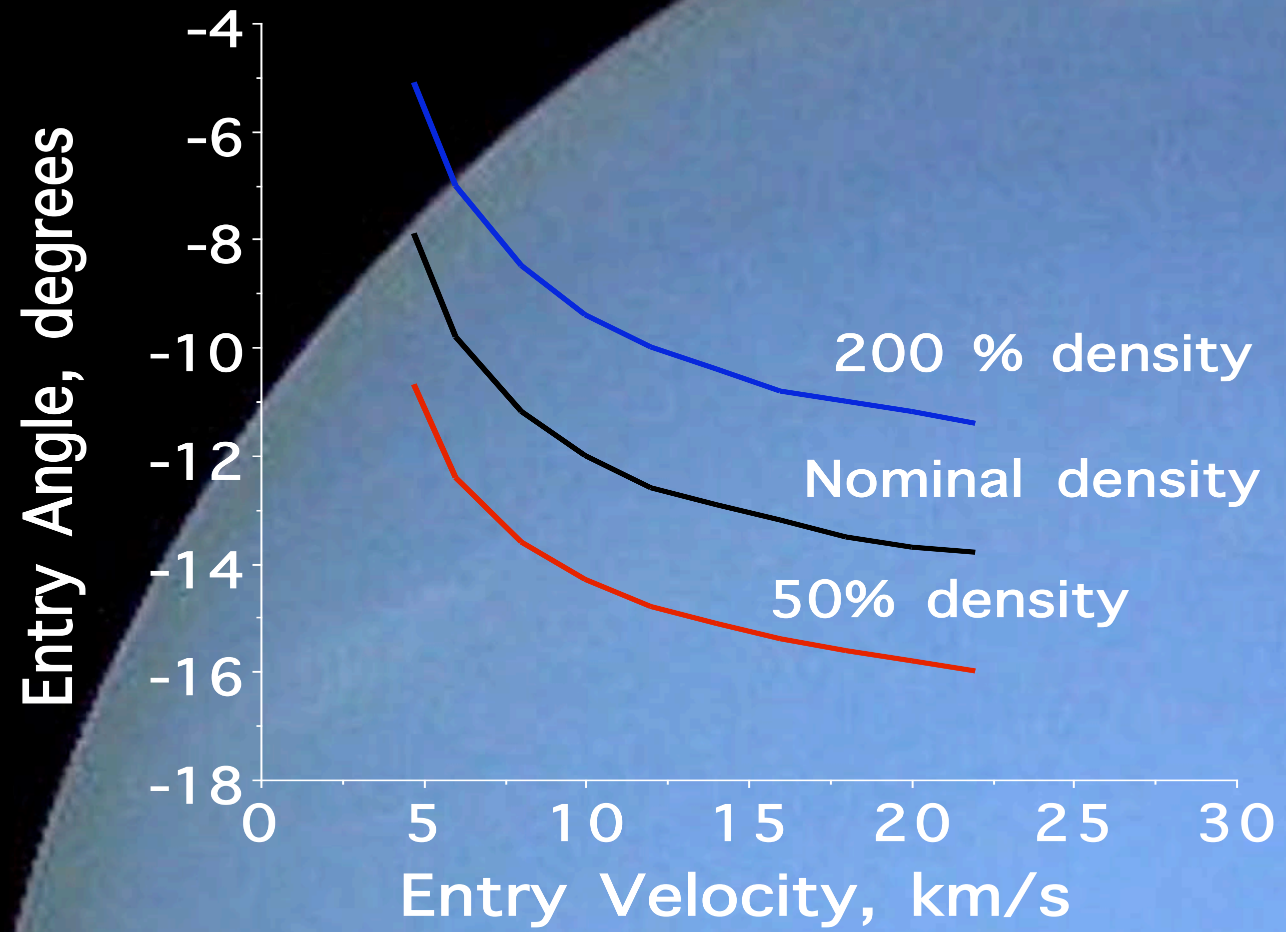
Influence of Ballute Size on the Required Entry Angle for a Non-Releasing Trajectory



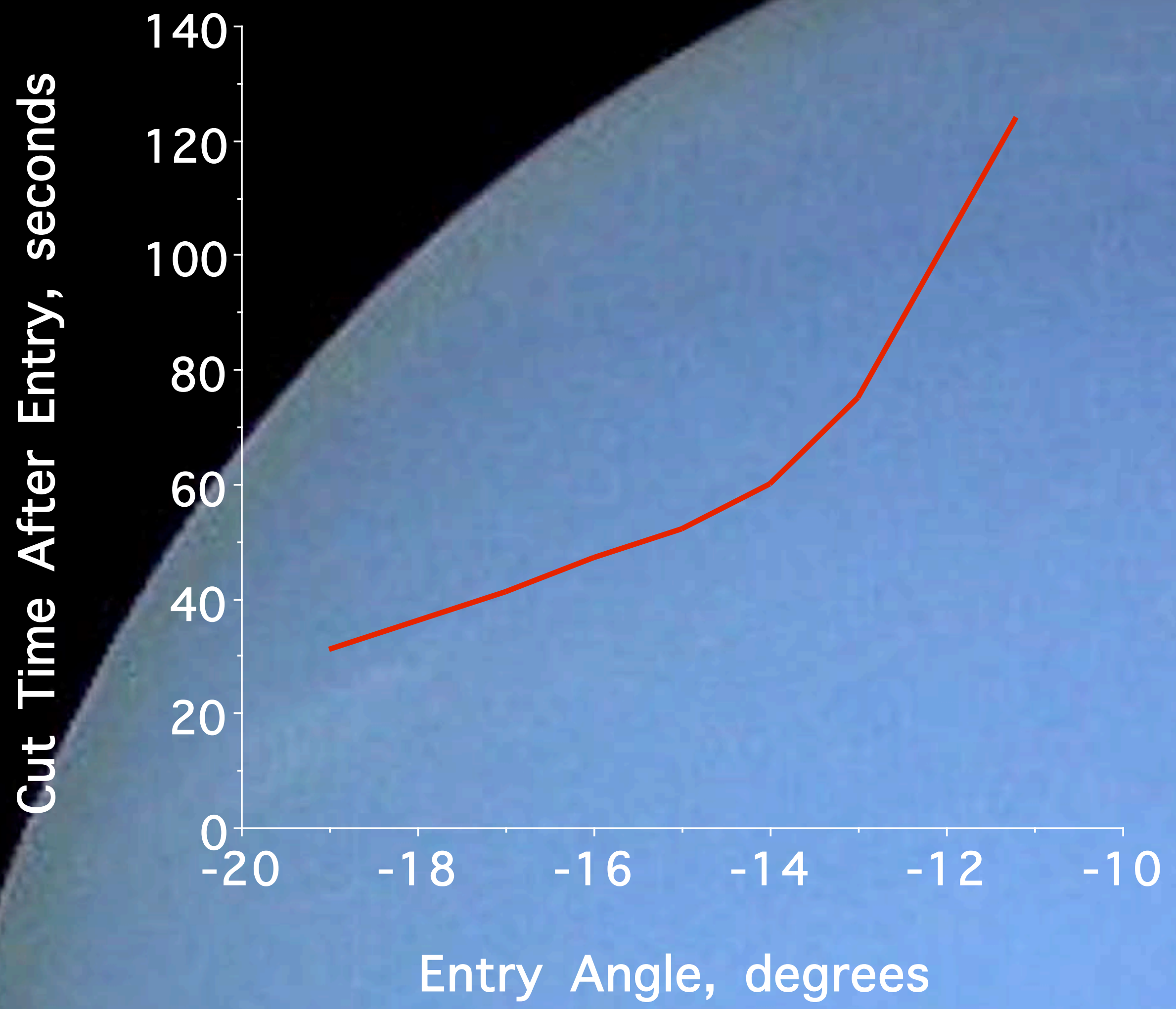
Exit Velocity Vs Entry Angle for a Non-Releasing 500 m^2 Ballute Entering at Various Speeds



Impact of Atmospheric Dispersions on the Required Entry Angle for a Non-Releasing 500 m^2 Ballute



Cut Time for 500 m^2 Ballute Entering at 8 km/s



Conclusions

Aerogravity assist at Triton/Neptune is probably not feasible using a blunt body, rigid aeroshell with a low L/D because of the significant potential variability in the atmospheric density, coupled with the low trajectories expected under nominal conditions *(i.e. crash probable)*

Ballutes offer substantial corridor width and high enough trajectories to merit further study

Future Work

An evaluation of aerodynamic heating and the design of nominal and off-nominal trajectories which meet the constraints of inflatable structures

Aeroshells with very low ballistic coefficients (such as designs using inflatable skirts) for Triton/Neptune AGA

High L/D rigid aeroshells (biconics and lifting bodies) should be examined

More work is required in collaboration with atmospheric scientists to determine the probable range of variability in Triton’s atmospheric structure

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